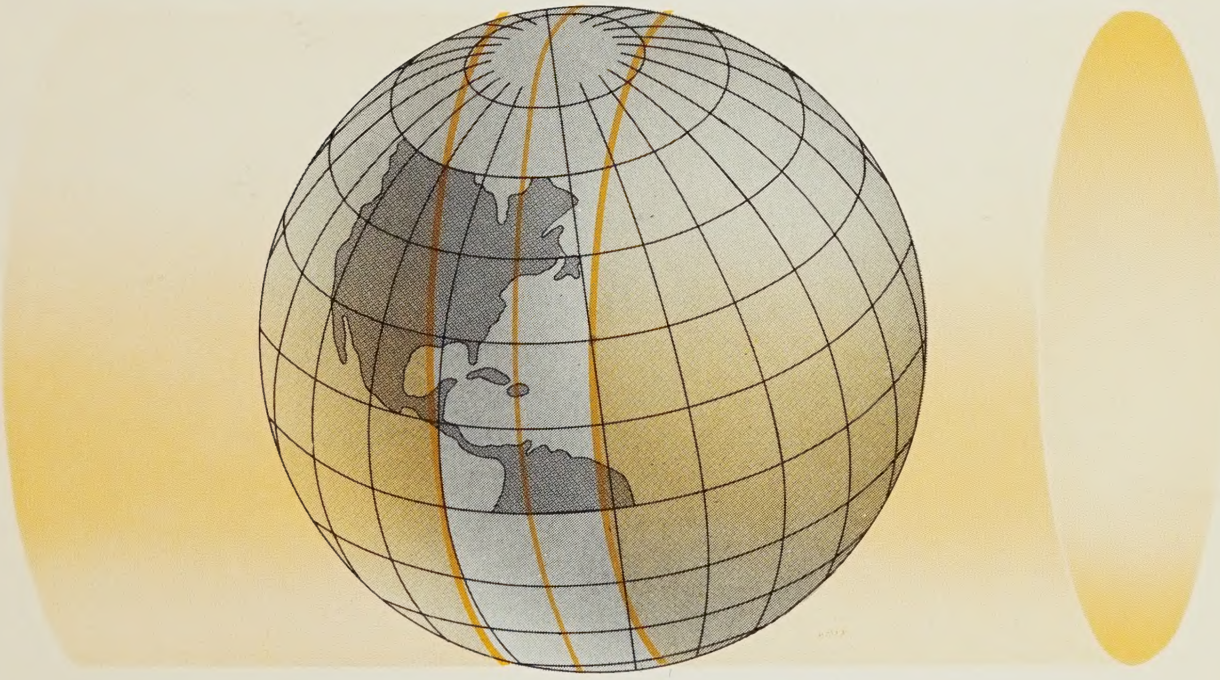
THE ONTARIO GEOGRAPHICAL REFERENCING GRID

(THE UNIVERSAL TRANSVERSE MERCATOR GRID SYSTEM)



Ministry of
Natural
Resources

Ontario

THE ONTARIO GEOGRAPHICAL REFERENCING GRID

(The Universal Transverse Mercator Grid System)

Prepared by

Ministry of Natural Resources
Surveys and Mapping Branch
Geographical Referencing Section

With the Assistance of
The Interministerial Committee on Geographical Referencing

May 1981

Ontario
Ministry of Natural Resources
Hon. Alan W. Pope
Minister
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Foreword

Government ministries, departments, agencies and municipalities are custodians of enormous and continually increasing quantities of resource, demographic, socio-economic and other data which can be fixed or referenced to a specific, geographical location on some type of map or reference base. Effective resource management and integrated planning at the municipal, provincial and federal levels are highly dependent upon a manager's ability to access and correlate such data. Yet much of this data cannot be correlated because of the variety of incompatible methods and reference bases used to record, store and reference it.

The first step has already been taken to remedy this situation. The Government of Ontario as a matter of policy has adopted the Universal Transverse Mercator Grid System as the official standard geographical referencing grid for the Province. It is called the "Ontario Geographical Referencing Grid". A summary of the background leading to its adoption is included as an Appendix.

The Ontario Geographical Referencing Grid and a systematic series of grid cells based on it are described in this publication.

Alan W. Pope
Minister of Natural Resources

May 1981

1.0 THE UNIVERSAL TRANSVERSE MERCATOR (UTM) GRID SYSTEM

1.1 Rationale for Adoption of the UTM Grid in Ontario

In 1974 the Task Force on Geographical Referencing (TFOGR) was established by the Minister of Natural Resources with the following objectives:

(1) To define one comprehensive system which permits the visual and rapid geographical correlation of the physical properties, resources, legal status and use of the land in the Province of Ontario, and

(2) To determine alternative ways for the implementation of the system.

The Task Force recommended that for geographical referencing, the Province adopt one grid system and that this system be the UTM grid system.[1]

To provide for the use of this grid, agreement on a provincial mapping policy was obtained by the Ministry of Natural Resources (MNR) and a program to produce basic maps showing the grid was initiated by it.

In addition to the responsibility for implementing the basic mapping program, the Minister of Natural Resources was authorized to maintain the integrity of the provincial referencing grid. To this end an organization has been established in MNR to implement a provincial horizontal control survey data bank.

Furthermore, an Interministerial Committee on Geographical Referencing (I-COGR) has been established to assist in the development of the comprehensive system defined in the TFOGR objectives. ICOGR also provides a forum for the exchange of information on geographical referencing activities, identifies needs for and develops and promotes the use of provincial standards.

ICOGR has examined and reaffirmed the choice of the Universal Transverse Mercator grid system as the geographical referencing grid with the most advantages and fewest disadvantages. Points in favour of the UTM include:

- it is a systematic, conformal, mathematically defined coordinate system;
- it is extensively used throughout Ontario by many provincial and federal government departments;
- it is a metric system;

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[1] Ontario, Ministry of Natural Resources, Surveys and Mapping Branch, Task Force on Geographical Referencing, *Map Use, Map Requirements and Recommendations for Basic Mapping*, Geographical Referencing Report 2 [Toronto, 1975], p. 44.

- it is the grid used on maps produced under the Ontario Basic Mapping program and on the 1:250 000 and larger scale National Topographic System of maps;
- there are only three UTM zone boundaries in Ontario;
- for a given spheroid one table only is required for the computation from geographic to grid coordinates and only one table is required for the inverse computation.

Not in favour of the UTM is the fact that:

- it is necessary to apply a scale correction to a distance measured on the ground in order to reduce or convert it to grid distance.

Background and further rationale for adoption of UTM are given in Appendix "B".

Under ICOGR's terms of reference, it is also responsible for determining the series of grid cells that would be most effective for facilitating the aggregation, transfer or analysis of demographic, resource and other information by other than the original user. The series of grid cells selected is structured on the UTM grid and is described in the second section of this publication.

1.2 Historical Development

Over the centuries, man has devised numerous projections in an attempt to better represent the curved surface of the earth on the plane surface of a map. Many of history's great mathematicians have wrestled with this problem, not the least of whom was Gerhardus Mercator. Mercator was the first to apply the projection which bears his name, that is, the Mercator projection, when he produced his famous world chart in 1569.

In the Mercator chart, the meridians of longitude are displayed parallel to one another, and the parallels of latitude are straight lines whose distance from one another increases with their distance from the equator (See figure 1a). Mercator charts are of great value in navigation since all lines of constant azimuth appear as straight lines. A second advantage is that the scale is the same in all directions, and although it varies from point to point, any small area is represented in its true shape. The only place where the Mercator chart is true to scale, however, is along the equator.

Mercator actually derived his projection using mathematical formulae. For conceptual purposes, however, the Mercator projection may be viewed as a projection of points onto a cylinder assumed to be wrapped around the earth tangent to the equator (See Figure 1). This conceptual view is not an authentic Mercator projection but actually is a cylindrical perspective projection.

Conceptual view of Mercator projection

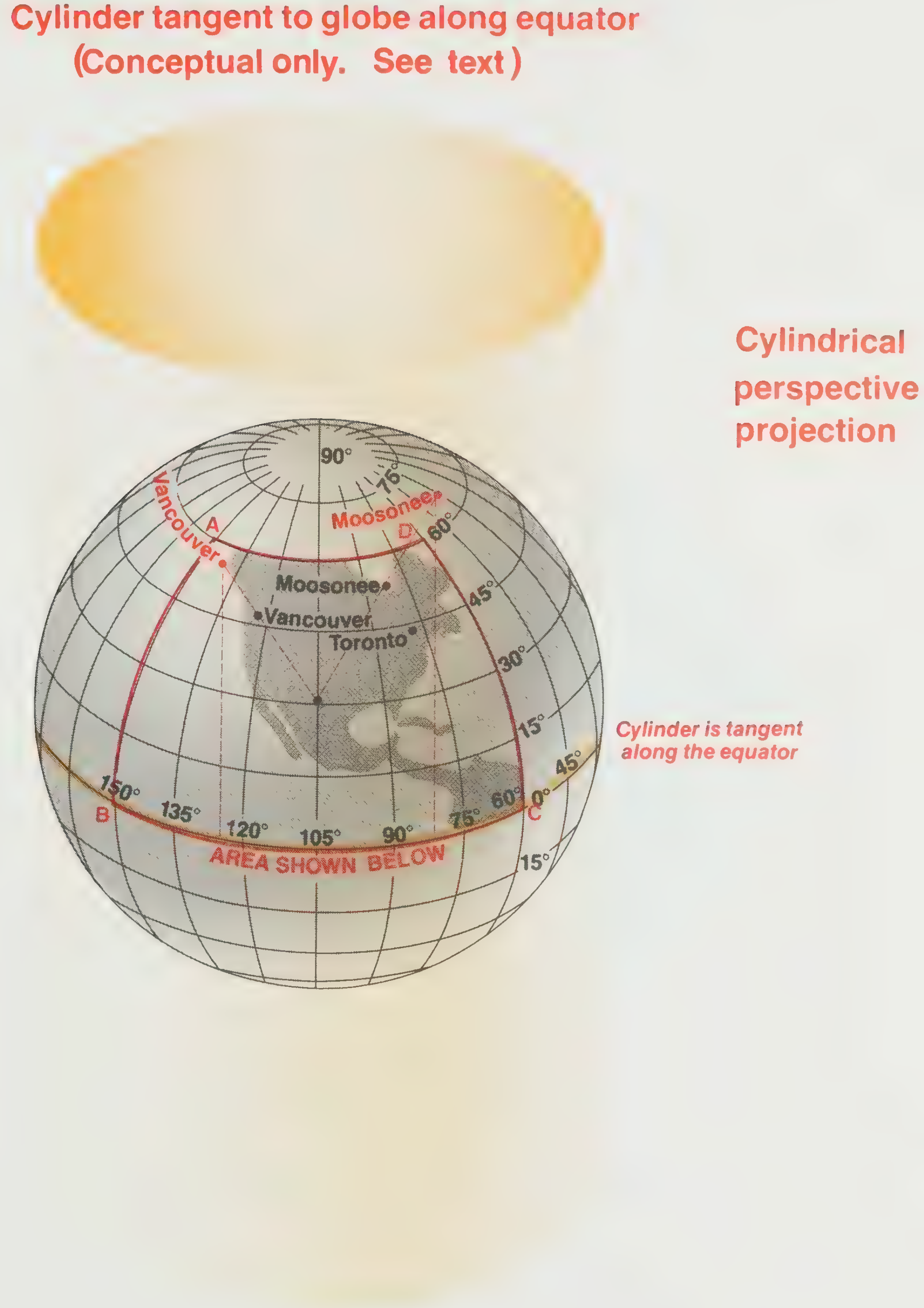
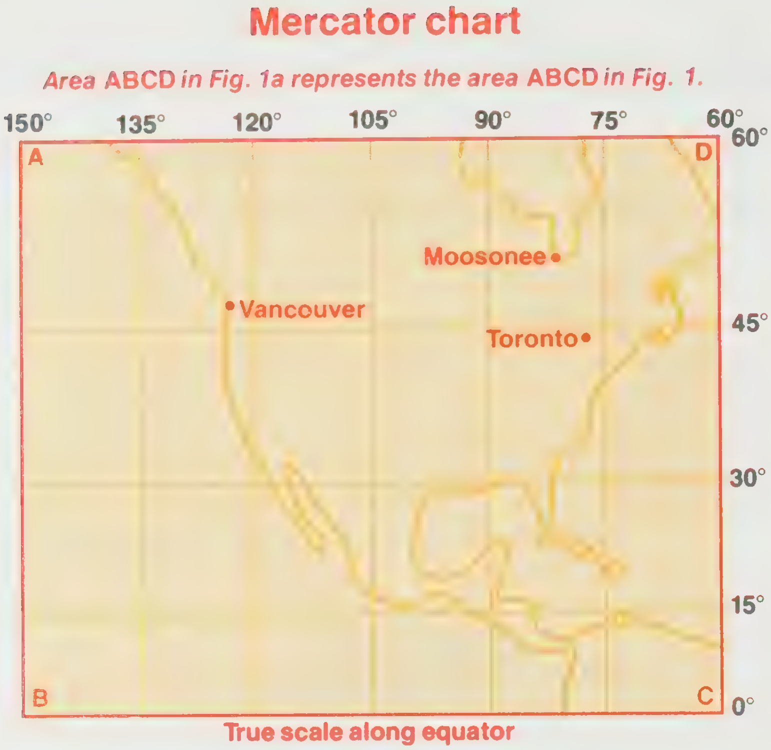


Fig 1

Fig 1a



The next milestone in the evolutionary process toward the UTM was the development of the Transverse Mercator projection. Its invention early in the nineteenth century is credited to Karl Friedrich Gauss. The Tranverse Mercator is similar in principle to the cylindrical perspective projection except the cylinder is placed tangent to the central meridian of the area to be mapped rather than tangent to the equator (See Figure 2).

In this projection, true scale is maintained only along the central meridian. If the radius of the cylinder is reduced, however, it can be made to intersect the surface of the globe along two arcs parallel to the central meridian. Thus, scale distortion is introduced at the central meridian but true scale is preserved along the two arcs of intersection (See Figure 3). This adaptation was a further development toward the UTM grid system. The Transverse Mercator projection has been used for many years by a variety of countries, particularly in the production of military mapping.

In 1936 the International Union of Geodesy and Geophysics proposed the universal adoption of the Transverse Mercator projection in six-degree bands. In 1947, following years of analysis, the United States Army adopted as its official projection and grid the Transverse Mercator projection in six-degree bands with certain other modifications. These included a scale reduction of 1 part in 2500 at the central meridian, a definition of the vertical coverage from 80° South latitude to 80° North latitude and the use of metric units. The fact that new features were incorporated into the Transverse Mercator projection, the proposed use of the new system for the U. S. Army's world-wide mapping program, and its possible adoption by other nations led to its designation as the *Universal Transverse Mercator* (See Figure 3).

Transverse Mercator projection

Cylinder tangent to globe along central meridian

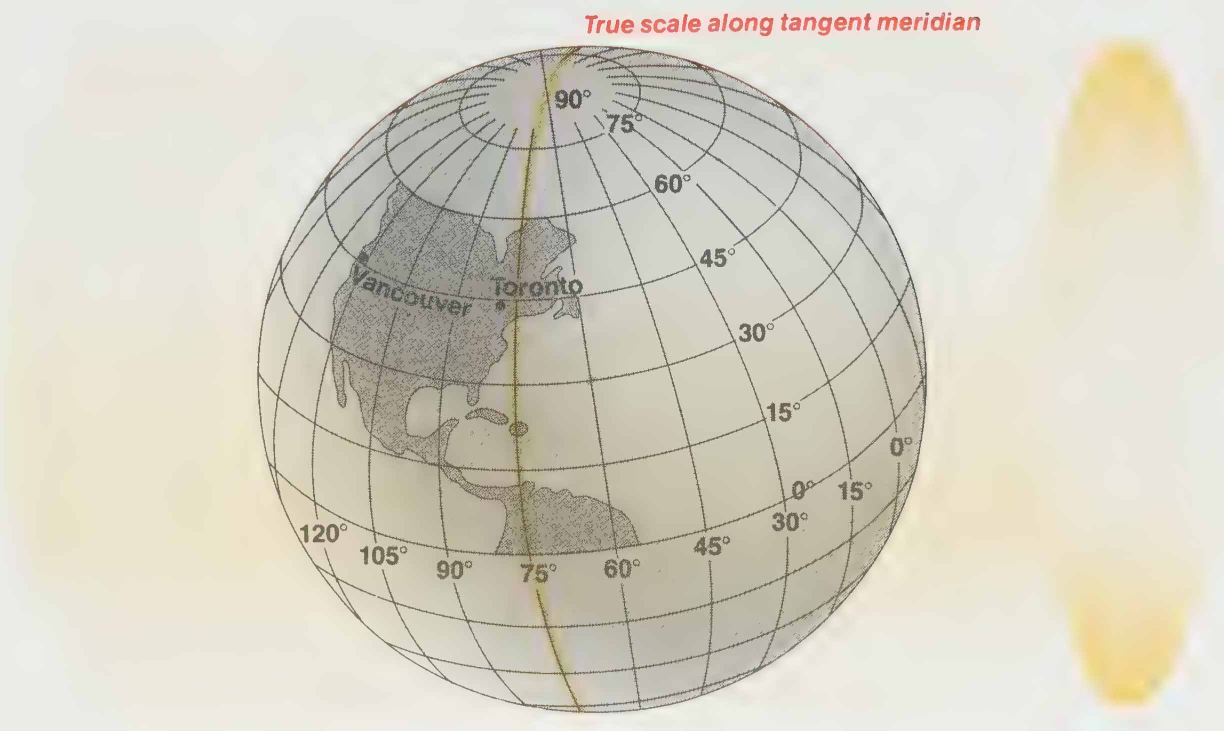


Fig. 2

Universal Transverse Mercator

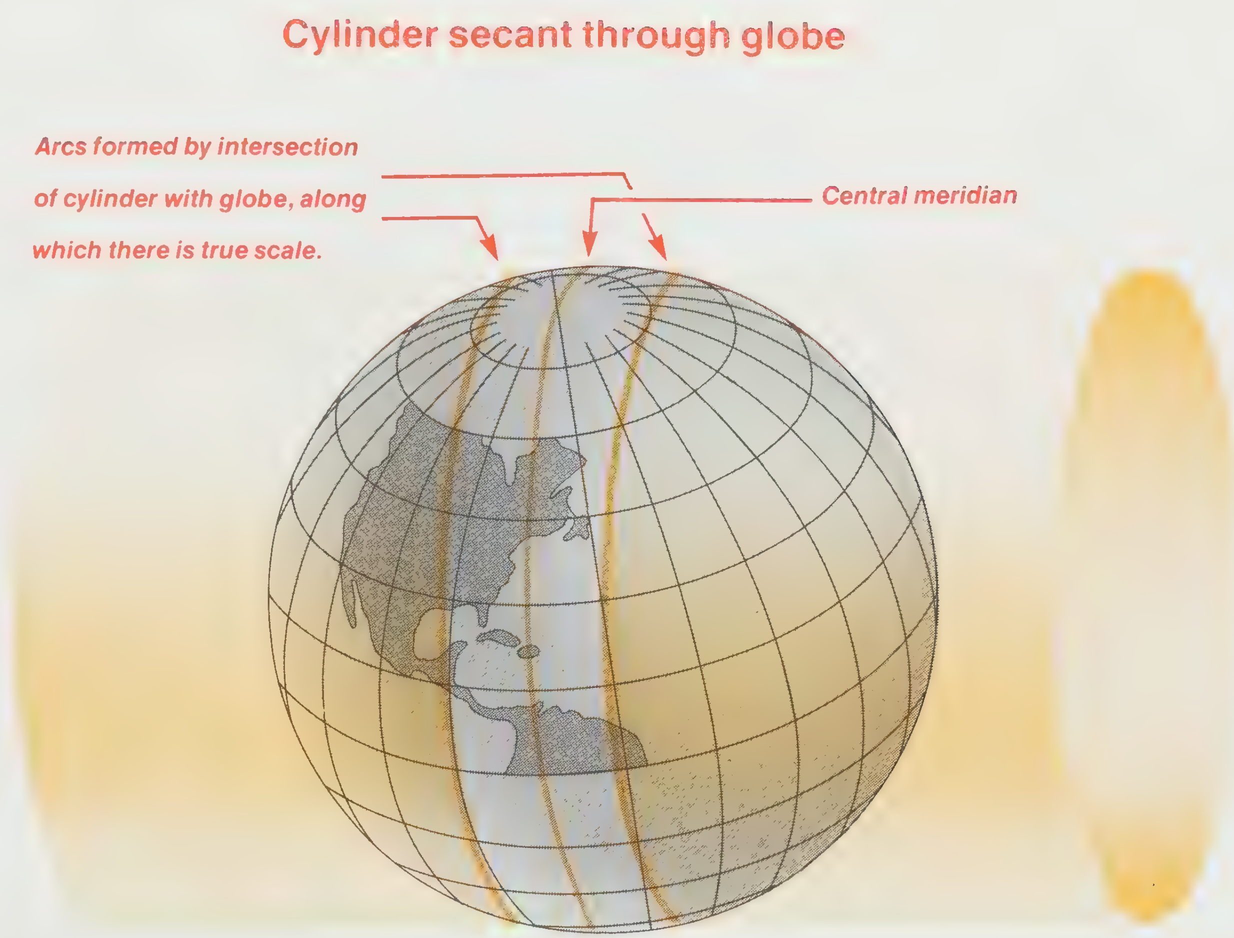


Fig. 3

Since that time the UTM has been accepted by the North Atlantic Treaty Organization and by many other countries as their official grid system for military purposes. The recommendation of its adoption for topographic mapping by organizations such as the International Union of Geodesy and Geophysics, the Pan American Institute of Geography and History, and the British Commonwealth Survey Officers Conference (1951) attests to the soundness of design and adaptability of the UTM for topographic mapping and survey purposes.

1.3 Characteristics

(a) The projection is the Transverse Mercator in zones six degrees wide. The zones are even multiples of 6° (longitude) and are numbered from west to east, commencing at longitude 180°. Ontario lies in four UTM grid zones, i.e. 15, 16, 17 and 18 (See Figure 4).

Zone 15 lies between meridians of longitude 96°W and 90°W.

Zone 16 lies between meridians of longitude 90°W and 84°W.

Zone 17 lies between meridians of longitude 84°W and 78°W.

Zone 18 lies between meridians of longitude 78°W and 72°W.

(b) The longitude of origin for each zone is its central meridian. Each central meridian is assigned a grid easting of 500 000 m in order to avoid negative numbers for coordinate values of points lying west of the central meridian.

(c) The scale factor at the central meridian of each zone is 0.9996.

(d) The latitude of origin is the equator, which is assigned a grid northing of zero metres.

(e) Grid coordinate values are expressed with the easting ordinate preceding the northing ordinate.

(f) The unit of measurement in which coordinates are expressed is the metre.

(g) The reference spheroid utilized at present in North America is the Clarke Spheroid of 1866 with minor variations to Clarke's measurements of the equatorial and polar semi-axes. The equatorial semi-axis (a) is defined as 6 378 206.4 m; the polar semi-axis (b) as 6 356 583.8 m and the flattening (f) as 0.003390075.

NOTE: $f = \dfrac{a - b}{a}$

(There are 0.3048 international metres in one imperial foot.)

UTM Zones in Ontario

Fig 4

1.4 Scale Factor

The relationship between any two points on the earth's surface may be expressed in terms of distance and direction. One can determine distance by measuring it from a map or by calculating it mathematically from the grid coordinates of the two points in question. In either case, it is called the grid distance or sometimes the map distance. The distance can also be determined by measurements taken on the ground, in which case it is termed the ground distance. These distances are rarely identical due to the inevitable distortion created in displaying a curved surface (the earth) on a plane (a map). In order to convert ground distance to grid distance or vice versa, a scale factor must be applied. The scale factor changes from point to point, but so slowly that in general it may be taken as a constant within any 10 km x 10 km square.

In the Universal Transverse Mercator (UTM), as shown in Figure 3, the radius of the projection cylinder is reduced so that it is secant to the spheroid rather than tangent at the central meridian as in the Transverse Mercator. This keeps the scale error within tolerable limits throughout the zone so that nowhere does grid distance differ from ground distance by more that 4 parts in 10 000. For example, the scale factor for the UTM is 0.9996 along the central meridian of each zone, and it is unity along the two arcs formed by the path of intersection of the projection cylinder with the spheroid, approximately 180 km on either side of the central meridian (See Figure 5). At latitude 43° North, the scale factor at the zone boundaries is 1.000336.

Eastward or westward from the central meridian, the scale factor for the UTM varies for most purposes in accordance with the formula:

$$K = K_o \left[1 + \frac{X^2}{2R^2} \right]$$

Where K is the scale factor desired for the point in question,

$K_o = 0.9996$.

X is the scaled distance from the central meridian in metres,

R = 6 380 000 m (the mean radius of curvature of the spheroid).

A scale factor of 0.9996 introduces a scale error of one part in 2500, which is too large to ignore for most purposes. Because of the magnitude of the scale error at the central meridian, some have mistakenly assumed the UTM is not sufficiently accurate for cadastral survey purposes. However, when the scale and elevation factors (See 1.5) are applied, the UTM may be used for all survey applications including those requiring first order accuracy.

TABLE I
UTM ZONE WIDTH IN KILOMETRES

North Latitude	Width in Kilometres
42°00′	497.11827
43°00′	489.25961
44°00′	481.25105
45°00′	473.09497
46°00′	464.79382
47°00′	456.35005
48°00′	447.76621
49°00′	439.04485
50°00′	430.18862

1.5 Elevation Factor

Since elevation varies from place to place, measurements made on the ground must be reduced to a common surface or reference datum in order to eliminate problems arising from differences in elevation. At present the UTM grid in North America is referenced to Clarke's Spheroid of 1866, the surface of which is very close to mean sea level. Thus, measurements taken during precise surveys should be reduced to mean sea level distances before any computations for adjustments and analysis are begun. This is done by multiplying ground measurements by an elevation factor obtained with the following formula:

$$M_e = \frac{R}{R + h}$$

Where M_e is the elevation factor,
h is the mean elevation of the line above mean sea level, and
R is the mean radius of curvature of the earth.

The mean radius of curvature in Ontario for the mean latitude is approximately 6 380 000 m. To reduce a ground measurement taken at an elevation of 300 m above mean sea level to the reference spheroid the measurement must be multiplied by:

$$M_e = \frac{6\,380\,000}{6\,380\,000 + 300} = 0.99995298$$

Universal Transverse Mercator

Cross section of 6° zone (UTM)

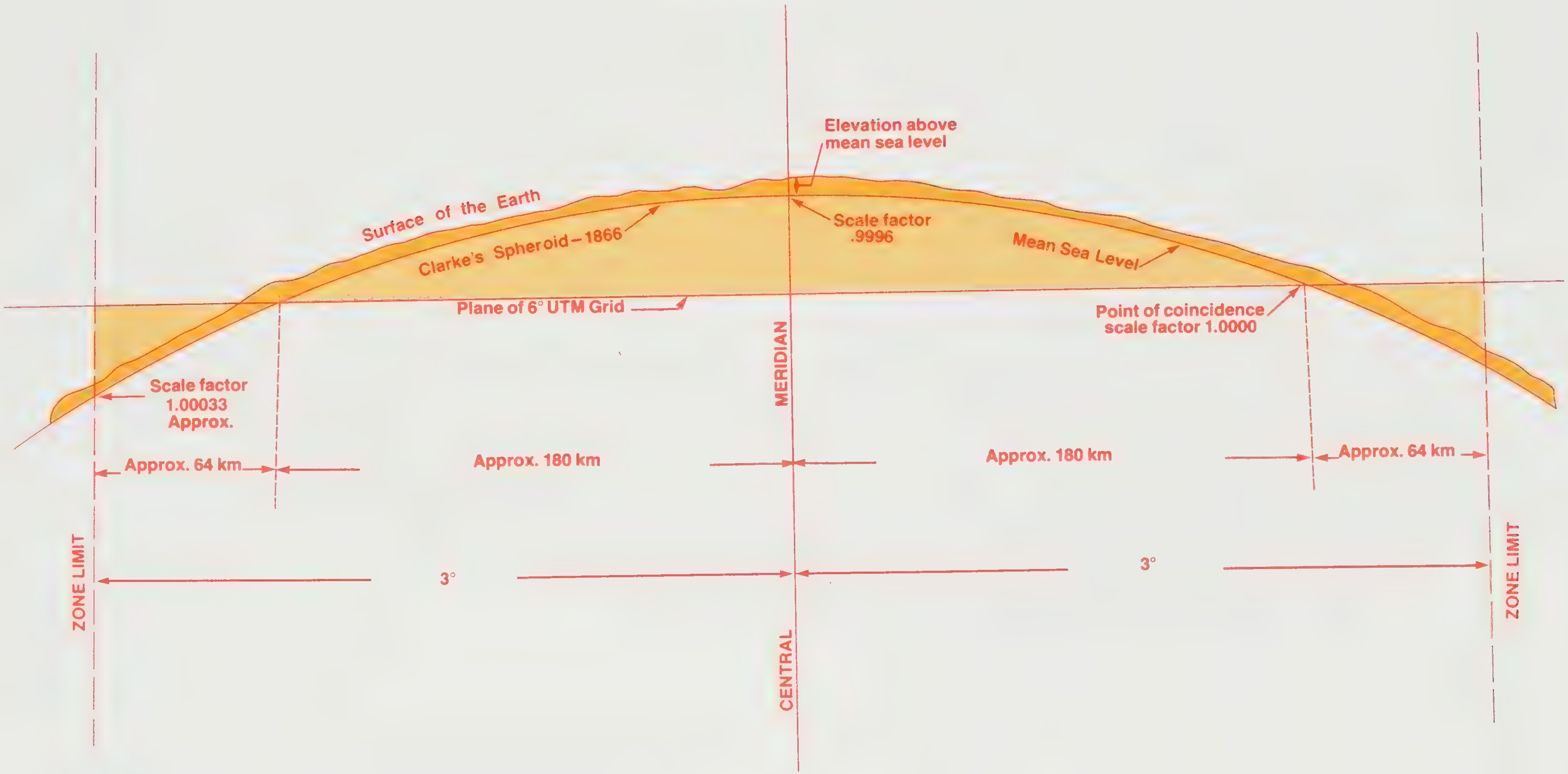


Fig 5

Universal Transverse Mercator

Cross section showing measurement along the central meridian of a UTM zone.

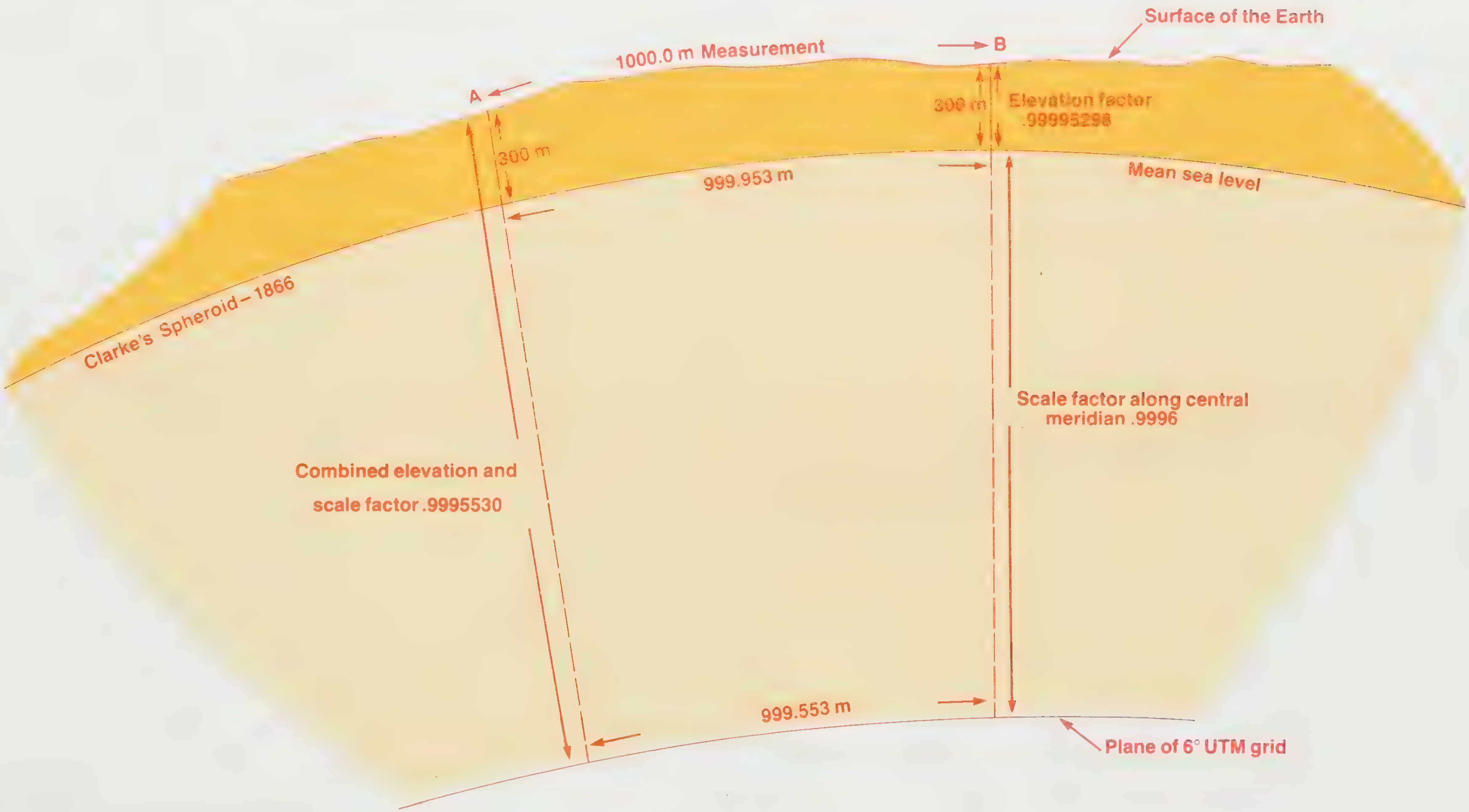


Fig 6

1.6 Combined Scale Factor

The combined scale factor is the product of the scale factor and the elevation factor, i.e. $M_c = K \times M_e$.

Where M_c is the combined scale factor,
K is the scale factor at the point in question, and
M_e is the elevation factor.

Thus a ground measurement of 1000 m, taken at an elevation of 300 m above sea level at the central meridian of a 6° UTM zone (Figure 6), is reduced to a 6° UTM grid distance as follows:

$$1000 \times M_c = 1000 \times 0.9995530 = 999.553 \text{ m}$$

Note that M_c was derived by multiplying the scale factor at the central meridian (0.9996) by the elevation factor for 300 m above sea level (0.99995298).

Conversely, a 6° UTM grid distance of 999.553 m at the central meridian would become a ground distance of 1000 m where elevation is 300 m above mean sea level:

$$\text{e.g. } \frac{999.553}{M_c} = \frac{999.553}{0.9995530} = 1000 \text{ m}$$

The following table (Table II) provides combined scale factors (the product of the scale factor and the elevation factor) suitable for use at any latitude in Ontario. Combined scale factors are given for points at 10 km intervals from the central meridian with elevations ranging from 0 m to 1000 m, in 100 m intervals.

TABLE II

COMBINED SCALE FACTORS (UTM)

ELEVATION ABOVE MEAN SEA LEVEL IN METRES

DISTANCE FROM CENTRAL MERIDIAN IN KILOMETRES	0	100	200	300	400	500	600	700	800	900	1000
0	0.999600	0.999584	0.999569	0.999553	0.999537	0.999522	0.999506	0.999490	0.999475	0.999459	0.999443
10	0.999601	0.999586	0.999570	0.999554	0.999539	0.999523	0.999507	0.999492	0.999476	0.999460	0.999445
20	0.999605	0.999589	0.999574	0.999558	0.999542	0.999527	0.999511	0.999495	0.999480	0.999464	0.999448
30	0.999611	0.999595	0.999580	0.999564	0.999548	0.999533	0.999517	0.999501	0.999486	0.999470	0.999454
40	0.999620	0.999604	0.999588	0.999573	0.999557	0.999541	0.999526	0.999510	0.999494	0.999479	0.999463
50	0.999631	0.999615	0.999599	0.999584	0.999568	0.999552	0.999537	0.999521	0.999505	0.999490	0.999474
60	0.999644	0.999629	0.999613	0.999597	0.999582	0.999566	0.999550	0.999535	0.999519	0.999503	0.999488
70	0.999660	0.999645	0.999629	0.999613	0.999598	0.999582	0.999566	0.999551	0.999535	0.999519	0.999504
80	0.999679	0.999663	0.999647	0.999632	0.999616	0.999600	0.999585	0.999569	0.999553	0.999538	0.999522
90	0.999700	0.999684	0.999668	0.999653	0.999637	0.999621	0.999606	0.999590	0.999574	0.999559	0.999543
100	0.999723	0.999707	0.999692	0.999676	0.999660	0.999645	0.999629	0.999613	0.999598	0.999582	0.999566
110	0.999749	0.999733	0.999717	0.999702	0.999686	0.999670	0.999655	0.999639	0.999623	0.999608	0.999592
120	0.999777	0.999761	0.999746	0.999730	0.999714	0.999699	0.999683	0.999667	0.999652	0.999636	0.999620
130	0.999808	0.999792	0.999777	0.999761	0.999745	0.999730	0.999714	0.999698	0.999683	0.999667	0.999651
140	0.999841	0.999825	0.999810	0.999794	0.999778	0.999763	0.999747	0.999731	0.999716	0.999700	0.999684
150	0.999877	0.999861	0.999845	0.999830	0.999814	0.999798	0.999783	0.999767	0.999751	0.999736	0.999720
160	0.999915	0.999899	0.999884	0.999868	0.999852	0.999837	0.999821	0.999805	0.999790	0.999774	0.999758
170	0.999955	0.999940	0.999924	0.999908	0.999893	0.999877	0.999861	0.999846	0.999830	0.999814	0.999799
180	0.999999	0.999983	0.999967	0.999952	0.999936	0.999920	0.999905	0.999889	0.999873	0.999858	0.999842
190	1.000044	1.000028	1.000013	0.999997	0.999981	0.999966	0.999950	0.999934	0.999919	0.999903	0.999887
200	1.000092	1.000076	1.000061	1.000045	1.000029	1.000014	0.999998	0.999982	0.999967	0.999951	0.999935
210	1.000142	1.000127	1.000111	1.000095	1.000080	1.000064	1.000048	1.000033	1.000017	1.000001	0.999986
220	1.000195	1.000180	1.000164	1.000148	1.000133	1.000117	1.000101	1.000086	1.000070	1.000054	1.000039
230	1.000251	1.000235	1.000219	1.000204	1.000188	1.000172	1.000157	1.000141	1.000125	1.000110	1.000094
240	1.000309	1.000293	1.000277	1.000262	1.000246	1.000230	1.000215	1.000199	1.000183	1.000168	1.000152
250	1.000369	1.000353	1.000338	1.000322	1.000306	1.000290	1.000275	1.000259	1.000243	1.000228	1.000212

2.0 A SYSTEMATIC SERIES OF GRID CELLS

2.1 Introduction

It is generally necessary to describe the geographical location of data by referring to its position in terms of points, line segments, polygons or grid cells. For example, a control survey monument's position can be described by a single point, the water boundary of a land parcel by a line segment, and the area of an oil field or forest stand can be displayed on a map as a polygon. The design and authorization of standards for each of these geographical referencing units is essential to the development of a comprehensive geographical referencing system for Ontario. This publication, however, addresses only one of these four basic reference units — the grid cell. Standards for the remaining three are now under development by the Interministerial Committee on Geographical Referencing.

Grid cells have been used by planners, ecologists, environmentalists and biologists, among others, to reference positionally related data and expedite its analysis. Previously, in the absence of a standard series of grid cells, users chose from an unlimited number of alternatives, the size, shape and orientation of cells as well as the axis of origin and the method of indexing the cells within the area of study. Since the cells were generally chosen to serve the study at hand with no consideration for the needs of other potential users, the data could seldom be used by any but those for whom it was originally gathered.

In 1978, ICOGR formed a Task Force on Grid Cells and Geocodes. One of the Task Force objectives was to determine the series of cell sizes, structured on the UTM grid, that would be most effective in the aggregation, correlation and analysis of demographic, resource and other positionally related information. The proposed series of cells was introduced at the Seminar on Geographical Referencing sponsored by ICOGR in September 1978[2]. Since then ICOGR has adopted this systematic series of grid cells (shown in Figure 7) as part of the provincial geographical referencing standards for Ontario.

2.2 Cell Sizes, Their Relationships and the UTM Grid

The chosen series comprises three tiers of cells in which each cell integrates evenly into the one below it on a 1:10 linear and 1:100 areal basis. Additionally, as shown in Figure 7, the cells integrate into the next larger cell to the right on a 1:2 linear and 1:4 areal basis. Diagonally from northeast to southwest the cells integrate evenly into the next larger cell on a 1:5 linear and 1:25 areal basis. Diagonally from northwest to southeast they integrate into the next larger cell on a 1:20 linear and 1:400 areal basis.

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[2]Ontario, Ministry of Natural Resources, Interministerial Committee on Geographical Referencing, *Proceedings of Seminar on Geographical Referencing*, [Toronto, September 1978] pp. 75-89.

A systematic series of grid cells based on the UTM grid

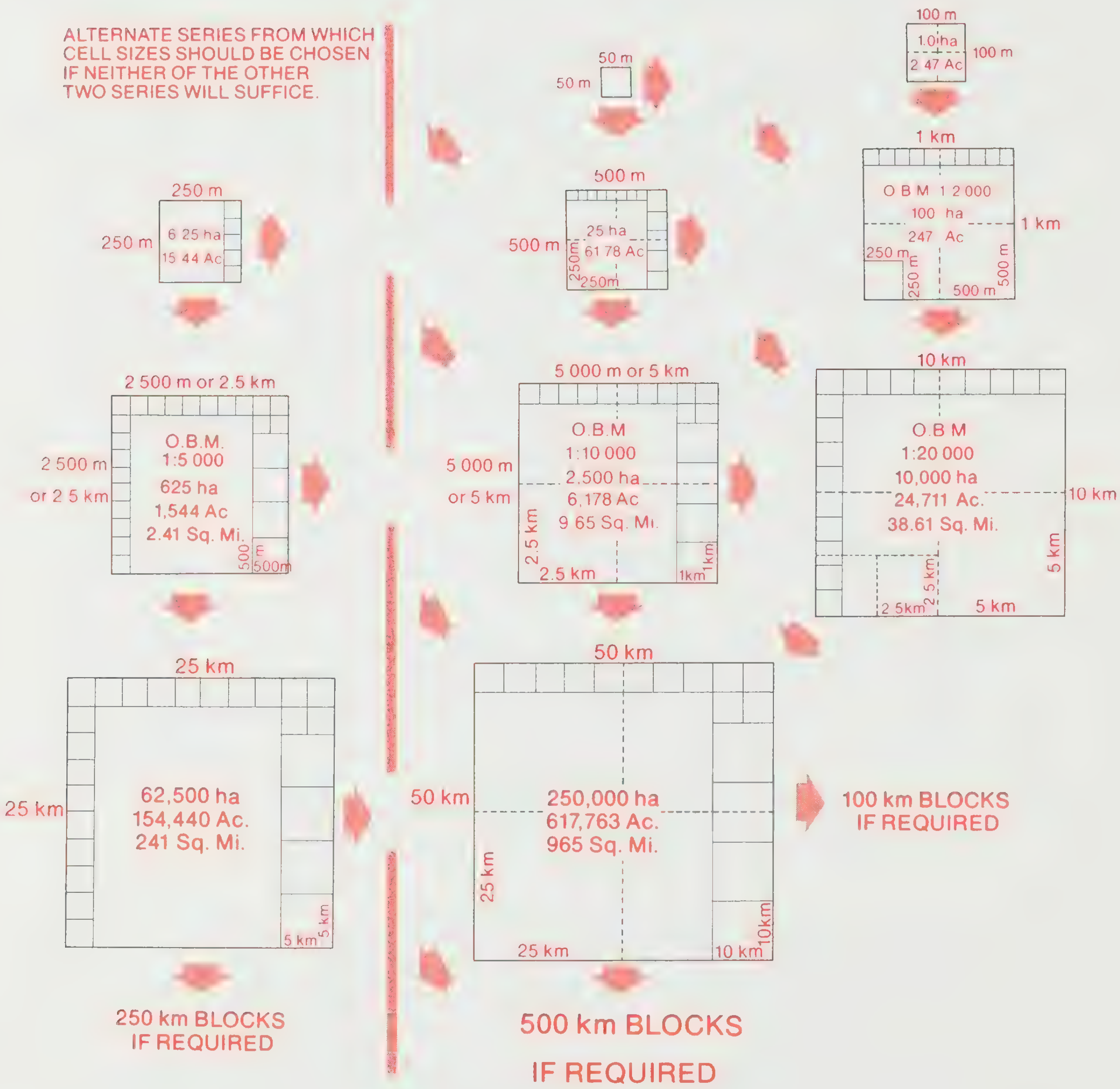

FIG 7

Grid cells as integral units of the UTM grid

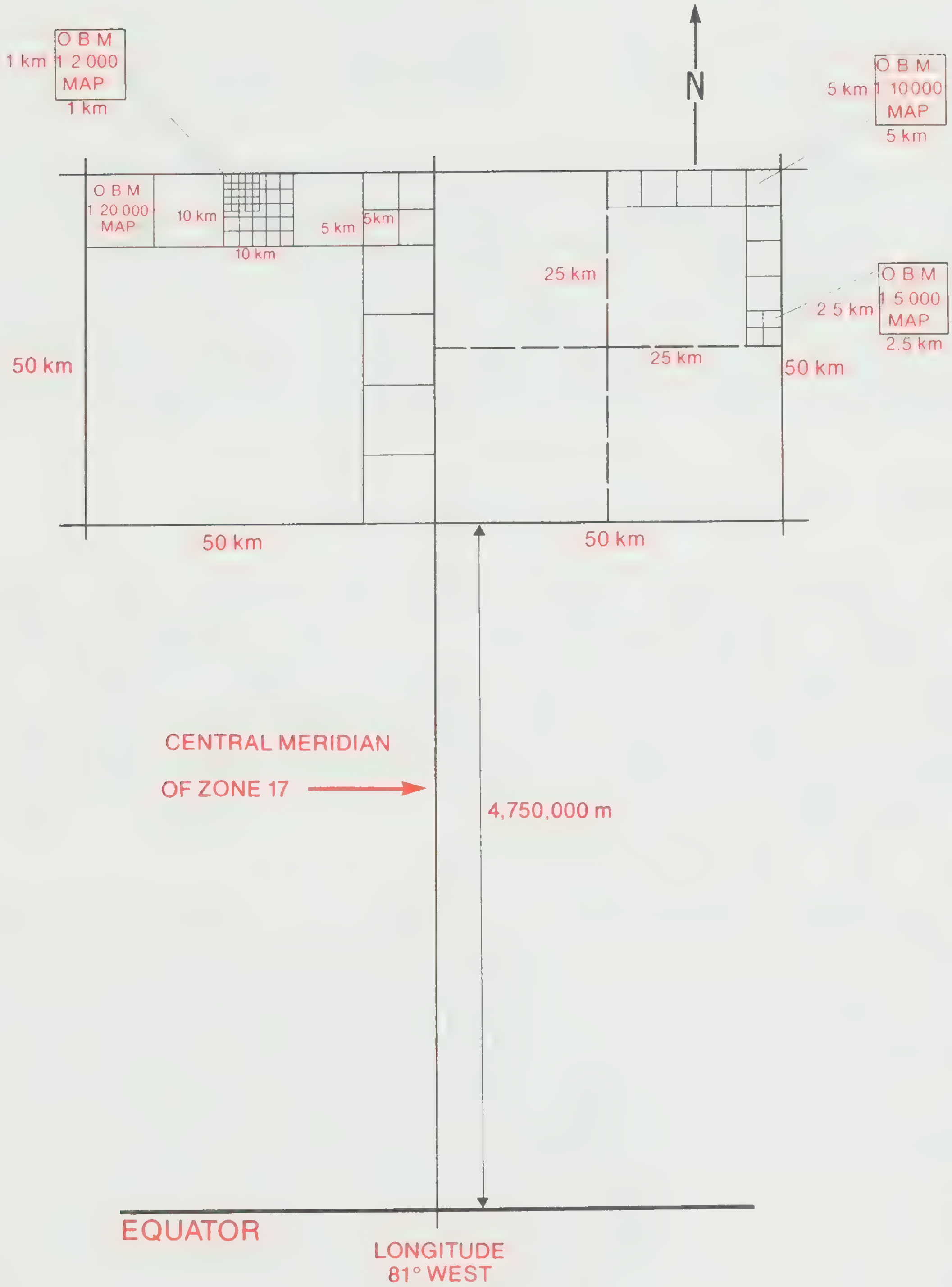

FIG 8

Figure 8 shows that the cells are integral units of the UTM grid. It can be seen that the cells are measured in discrete 50 km units both north from the equator and east and west from the central meridian of the zone in which they are located. These larger cells form the framework for the smaller cells, which can be grouped evenly in them. This not only facilitates the correlation of data and the aggregation of cell data into larger units, but also permits the use of a systematic indexing system.

2.3 Cell Indexing

The index to the standard grid cells is based on the UTM coordinates of the southwest corner of each cell. Specifically, grid cells designators comprise the UTM zone number in which the cell is located followed by the easting and then the northing of the southwest corner of the cell to the minimum number of digits necessary to uniquely identify the cell. The northing is followed by a number in parenthesis which provides the length of the sides of the cell expressed in kilometres. Table III provides sample designators for various sizes of grid cells.

2.4 Relationship of Cells to Ontario Basic Map Sheets

The series includes grid cells that coincide with Ontario Basic Maps. As Figure 7 shows, the 1 km grid cell corresponds to the OBM 1:2000 map, the 2.5 km grid cell to an OBM 1:5000 map, the 5 km grid cell to an OBM 1:10 000 map and the 10 km grid cell to the OBM 1:20 000 map. An advantage of this relationship is that thematic data collected on the basis of an Ontario Basic Map could be aggregated and analyzed by grid cell by other users interested in a more generalized picture of the Province's resources.

2.5 Cells at UTM Zone Boundaries

Since Ontario lies within four UTM zones, there are three zone boundaries to be accommodated in the referencing system. While most study areas analyzed by grid cell techniques will lie within a single zone, some will not. Where the area under consideration extends well into the adjacent zone or even beyond it, it is recommended that the grid cells be related to the central meridian of the zone in which they are located. In that case, cells will stop at zone boundaries regardless of whether they are complete or not. Such cells will vary in size and should be treated accordingly depending on user requirements. However, where the study area crosses a zone boundary but does not penetrate deeply into the adjacent zone, the zone boundary can be ignored. All cells may be treated as complete squares and be related to the central meridian of the zone in which the greater part of the study area lies.

TABLE III

SAMPLE DESIGNATORS FOR DIFFERENT SIZES OF GRID CELLS

Cell Size	UTM Zone	Coordinates of Southwest Corner of Cell to Nearest m Easting	Northing	Cell Length in km	Cell Designator
50 m x 50 m	17	550000	4755000	(0.05)	17 55000 475500(.05)
100 m x 100 m	17	550000	4755000	(0.1)	17 5500 47550(0.1)
500 m x 500 m	17	550000	4755000	(0.5)	17 5500 47550(0.5)
1 km x 1 km	17	550000	4755000	(1)	17 550 4755(1)
5 km x 5 km	17	550000	4755000	(5)	17 550 4755(5)
10 km x 10 km	17	550000	4750000	(10)	17 55 475(10)
50 km x 50 km	17	550000	4750000	(50)	17 55 475(50)
250 m x 250 m	17	550250	4752750	(0.25)	17 55025 475275(.25)
2.5 km x 2.5 km	17	550000	4752500	(2.5)	17 5500 47525(2.5)
25 km x 25 km	17	550000	4775000	(25)	17 550 4775(25)

2.6 Long Term Benefits

The grid cell is primarily an analytical tool. The proposed sequence in which the ratio of cell sizes never exceeds 2.5 from one size to the next provides a selection which should satisfy the cost and accuracy requirements of all users, while maintaining the advantages for data comparison and interchange. The use of such a systematic series of grid cells referenced to the UTM grid will also serve to precisely identify the location of data recorded on each cell which uniquely defines a specific part of Ontario. This means that in time as more agencies who use grid cells utilize this systematic series, more data will be permanently and accurately recorded against a unique, readily identifiable, integral unit on the earth's surface. As the amount of data associated with each cell grows, a more comprehensive picture of that specific part of Ontario will evolve. Furthermore, the data will not only be referenced by a method which tends to preserve the identity of its location, but by one which also makes it more accessible to and usable by all concerned.

APPENDIX "A"

EXPLANATION OF TERMS

Control Survey:

A Control Survey establishes, by precise surveying methods, coordinated position values for monumented points on the earth's surface and provides a reference framework to check and relate additional surveys and related activities such as mapping. Provincial control survey networks form the framework for the Ontario Geographical Referencing Grid.

Geographical Referencing:

The process of recording in a systematic and retrievable fashion the unique position or location on earth where something occurred or is located.

Grid Cell:

An arbitrary, two-dimensional ruling of the earth's surface for purposes of analysis.

Ontario Geographical Referencing Grid:

The grid adopted by Ontario as the official standard grid for referencing positionally related data. It is in fact the Universal Transverse Mercator Grid system.

Ontario Geographical Referencing System:

A comprehensive system which permits visual and rapid geographical correlation of the physical properties, resources, legal status and use of the land in the Province of Ontario. At present, the comprehensive system does not exist in its entirety. The aim is to develop and press for the adoption of a totally integrated set of geographical referencing standards, produce a systematic series of base maps, develop general purpose computer routines for handling and manipulating spatial data, and design and implement an integrated, distributed geographical referencing data base system which will facilitate and expedite the retrieval and correlation of positionally related information.

APPENDIX "B"

Coordinate Surveys in Ontario

In 1962 the Association of Ontario Land Surveyors submitted a brief to the Minister of the Department of Lands and Forests with recommendations for certain changes in the administration of land surveying in Ontario. One of the recommendations was that a province-wide horizontal control system of surveys be established. Studies were undertaken during the 1960s by Ontario, other provinces and the federal government to determine the most suitable system of surveys on a provincial and national basis. A system based on the Transverse Mercator projection modified to a three-degree zone (3° MTM) was being considered by the Surveys and Mapping Branch of the federal government's Department of Energy, Mines and Resources. This system was also considered by the provinces and while some adopted it, others (and the federal government) did not.

In the case of Ontario, a concensus of government departments was reached in the adoption of 3°MTM. Subsequently, The Surveys Act was amended in 1969 to provide for systems of coordinate surveys and a regulation was made under that Act defining the parameters and characteristics of one system, namely 3°MTM. It was called the "Ontario Coordinate System". In 1970-71 the Management Services Division of Treasury Board studied and reported to the Department of Lands and Forests on the costs and benefits of a provincial program of coordinate control surveys. In 1972 the Ministry of Natural Resources recommended the implementation of such a program, but that recommendation was turned down on the basis of its high cost. Although the program was never implemented as a provincial program, some agencies of government and municipalities in Ontario did adopt 3° MTM.

Geographical Referencing in Ontario

Various Ontario Government studies and reports were completed in the 1960s and 1970s on the problems of referencing information by position. Action resulting from those studies has lead to the adoption of the Universal Transverse Mercator grid system as the official standard geographical referencing grid system in Ontario. The following are two of the main points in the rationale for the adoption and implementation of UTM in Ontario:

- There should be only one grid (not two or more) by which to identify the location of positionally-related data in Ontario. Logically, it would be the one upon which the largest amount of data is now and will continue to be referenced. UTM is this grid. See reports of the Task Force on Geographical Referencing 1974-75.

- Due to the vast amounts of data exchanged between the government of Ontario and Canada, it is desirable that each government use a common referencing grid. UTM is the grid used by the federal government. (In 1976, Canada's Minister of

Energy, Mines and Resources advised Ontario's Minister of Natural Resources that UTM will continue to be used for federal topographical mapping in Canada, adding that he was gratified Ontario had decided to adopt this projection for the province.)

Basic to the successful use of any common grid is the idea that it must be displayed on maps which are readily available for geographical referencing purposes. A provincial program of providing UTM gridded topographical base maps was announced in May 1978. The program is being implemented.

Implementation of geographical referencing in Ontario has been the subject of study by the Interministerial Committee on Geographical Referencing (ICOGR). One of the concerns of this Committee has been the lack of a particular public announcement on information referencing policy, particularly as regards the grid. The foreword in this publication contains such a statement.

With current government emphasis on "deregulation", it is unlikely that a regulation will ever be made defining the Ontario Geographical Referencing Grid. Those who will be involved with the implementation of or conversion to an information referencing system employing a referencing grid should consider using only the official standard referencing grid. Those who would continue using 3°MTM or promoting its use should consider that the ministry which attempted unsuccessfully to introduce it as a system of coordinate surveys has dropped it and is converting programs already using it. After examining information referencing, the Ministry of Natural Resources recommended the UTM as a common referencing grid. In this it was supported by eighteen other ministries, numerous local authorities and other potential users — policy makers, engineers, planners, scientists and resource managers — in both government and the private sector. Regulation 809 under The Surveys Act defining 3°MTM remains in effect for the use of those who continue to employ that system. There is nothing mandatory about its use, however.

The "Grid Versus Ground Measurement" Argument

There are those who would argue that a grid other than UTM should have been selected as a referencing grid. ICOGR has requested that this publication contain reference to the arguments put forth.

In most projections, there is a difference between the grid distance and the ground distance between two fixed points on the earth's surface. This difference is reconciled by a scale factor which is applied to convert a grid distance to a ground distance and vice versa.

In Transverse Mercator projections, the smaller the zone width the smaller the difference between grid and ground distances. This gives rise to the argument advanced by some who are engaged in engineering and cadastral surveying that the most suitable grid is one where, for practical purposes, the difference between grid and ground distances is very small and can be taken to be one and the same — hence support for

zones smaller than 6°. However, many of those who advocated the use of the 3°MTM have found it does not give a close enough relationship between grid and ground distances, thus they would now advocate projections with zones smaller than 3°, e.g. 2°MTM or 1½°MTM.

Although the need to apply a scale factor is the main argument of those who hold UTM in disfavour, the fact remains that in most projections there is a grid/ground difference which should be accounted for depending on the accuracy requirements of the survey. In fact, some survey practitioners maintain that the scale factor should always be applied regardless of the projection and that its application is not that laborious a task.